Union Pacific Railroad.

REPORT

OF

JAMES T. HODGE, Esq.

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NEW YORK:

Wm. C. Bryant & Co., Printers, 41 Nassau Street, cor. Liberty.

1864.

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On the Coal Deposits in the Rocky Mountains.

To the President and Board of Directors of the
Union Pacific Railroad Company:

Gentlemen: In accordance with your instructions of October 15th, 1863, I proceeded forthwith to the Rocky Mountains for the purpose of investigating the capabilities of the region near the surveys for the Union Pacific Railroad, for making iron and producing mineral fuel.

By the overland stage line I reached the base of the Black Hills at Laporte, on the 1st of November, to find the country covered with snow, rendering geological explorations altogether impracticable. Here I was detained a week, waiting for the surveying party I was to join, which was fitting out at Denver.

On the 8th I had crossed the Black Hills, and in Laramie Plains I first had an opportunity of investigating the mineral character of the country. In the prairie hills, three miles south 30° east by compass, from the stage station, called "Big Laramie," (from the name of the river, on the banks of which it stands), I discovered a lean iron ore, intermixed with veins of calc-spar, outcropping in flat bands, almost black in color and in considerable quantity. Similar ore is again met with covering the surface of the prairie on a direct line toward the stage station. It is a hematite at the surface, probably from atmospheric oxidation of a carbonate of the character of the clay iron stone, such as is found in the coal measures. The geological formations in the vicinity are shales of olive, bluish, and brown colors, associated with slaty calcareous strata, which contain sharks' teeth and other fossils, that refer the group to the cretaceous period. Plates of selenite are abundant, scattered on the surface of the shales.

Over the plains nearer the mountains to the east, are occasionally met outcroppings of a reddish sandstone, and a very close-grained, compact limestone of light shades, flesh, straw, pink, blue, red, and some nearly white. This limestone would answer well for a flux in smelting iron ores. Coal is reported to be found near the forks of the Laramie in these plains, and is probably of similar character to the same mineral worked near Denver (to be afterwards noticed), which also is associated with iron ores and limestones.

Though the iron ores I discovered, appear too lean to be valuable, they afford a clew as to the geological relations of the ores of this region and the localities where they are most likely to be met with.

Approaching the Cheyenne Pass from the West, small rolled pieces of hematite are found, both in the wagon road and also on the side of a prairie hill a quarter of a mile north from it, which hill is capped by ragged ledges of red limestone in horizontal strata. The pieces of ore are smooth and hard, and the quality is excellent, but there is no certainty of quantity sufficient for working. Further explorations, however, may lead to more important discoveries. Should such be made, iron works might be established near the mountains, on one of the branches of Laramie River. Several tributaries to it of clear water, never failing, run through the valley, seldom, however, with sufficient fall to afford water-power. The limestones may be depended upon for flux; and fuel will be afforded either by the beds of mineral coal, or by the pines of the mountains. The region, however, is generally deficient in good timber; none is seen on the prairies, and the growth upon the mountains is scattered, and for the most part thin. It consists almost exclusively of pines, balsam fir, and quaking aspen. Of these the first will make suitable charcoal for smelting iron ores. Until recently such fuel alone supplied the blast-furnaces on the shores of the Chesapeake, at Baltimore and its vicinity. In the mountains further South I afterward found spruce trees accompanying the pines. The Medicine Bow Mountains, on the west side of Laramie Plains, appear to contain a heavier forest growth than the Black Hills, and should iron ore be found on that side of the plains, it might prove a better region for the

manufacture of iron than the eastern side. I proceeded as far west as Fort Halleck, on a branch of the Medicine Bow Creek, and at the northeast base of Medicine Bow Mountains, and sought to ascertain the locality of iron ore on this creek, reported by Mr. Engelmann, who accompanied the expedition of Lieut. Bryan. I saw the interpreter and guide of this expedition, Mr. Duval, who is still in Government employment at Fort Halleck. He was entirely ignorant of any such discovery. I learned, however, of the occurrence of coal-beds, said to be of large size, in the prairie hills six miles northeast from Fort Halleck, and made several ineffectual attempts to find them. The east side of the hill, where they were discovered, I found covered deep with snow, and though I remained eleven days at Fort Halleck in hope of a favorable time for exploration, it was for nearly the whole period almost impracticable for one to cross the prairies, and dangerous to leave the stage road. The wind every day blew with extraordinary fury, sweeping the snow forward, and piling it in deep drifts in the cañons and gulches, and on the lee or east side of the hills. For days together a man could with difficulty stand up against it, and the driving snow often prevented his seeing one hundred yards in any direction. During this time the thermometer ranged from zero to 10° below. It was the first day of December when I reluctantly left this portion of the Rocky Mountains, in despair of making in it any useful geological observations at so advanced and inclement a season.

Before going to Fort Halleck, I accompanied the surveying party of Mr. B. B. Brayton through the Black Hills, on the Cheyenne Pass, leading from Lodge Pole Creek to Salt Lake, and it is for the sake of completing my account of the plains west of the Black Hills, before proceeding to that of the mountain district and the plains to the east of it, that I have introduced above my remarks upon the country about Fort Halleck.

At the Cheyenne Pass the Black Hill range, extending due north and south, presents a very uniform slope on its western side, but little interrupted by cañons, such as are of frequent occurrence in other portions of the Rocky Mountains. This slope, nearly to the summit, is that of the limestone strata, which, uplifted from their horizontal position in the plains, here form

the outermost layers of the range. In a gorge near the base of the mountain they are exposed to the thickness of full twenty feet, which is probably but a small portion of the real thickness of the formation. The rock is in broad, flat blocks, admirably suited for building stones, and much of it, though never crystalline, appeared as if it might make a substantial marble of fair quality, but not of bright colors. I could discover no fossils in it. Beneath this rock, exposed in precipitous ledges along the gorges, and curving up from under it at the summit, is a red silicious sandstone, resembling the Devonian red sandstone of the Alleghanies. It covers the surface of the hills lying north of the Pass, spreading out over broad areas in nearly horizontal strata. These toward the east abut in bold cliffs, and next beyond them in this direction appear the granitic and porphyritic rocks, which make up the central portion of the range. The only distinct fossils I could find in the sandstone were small encrenites. Neither this formation nor the limestone is likely to afford any useful minerals, though the latter may possibly prove a repository in occasional localities of hematite. Professor James Hall, of Albany, to whom I have submitted specimens of both the limestone and sandstone, refers the group to the carboniferous formation of the age of the true coal measures.

The rocks which compose the mass of the Black Hills, are red granites, red sienites, and red porphyritic sienites. They form not only the high ragged peaks and groups of rough hills that lie to the north and south of the pass, but the smoother surface and prairie-like hills of the pass itself are also underlaid by the same formation. A peculiar feature it everywhere exhibits is a decided tendency to disintegrate and crumble into coarse angular fragments. The surface is very generally covered with these, which make a poor soil enough, but the very best of roads. The wagon-road through the pass, though unimproved by any labor upon it, is for the most part unsurpassed in smoothness and durability by any macadamized road. This tendency to disintegrate is also the cause of the numerous peaks and monument-shaped masses of all sizes, standing on the steep mountain slopes and summits, and also scattered over the smoother and level portions of the mountains.

Some of these appear like the boulders of northern latitudes, perched upon ledges, from which they could be easily tipped off. Others resemble icy masses along a frozen coast, as they melt away on the approach of spring. In some instances, when the disintegration has gone on most rapidly at the base of tower-like masses, huge blocks have parted from the main body to which they belonged, and have fallen down, exposing a fractured and nearly smooth face, sometimes of several hundred square feet area. In general, the outline produced by the disintegration is rounded like that of rolled boulders. I could find in these formations no metallic veins, nor any features that would lead me to look for iron ores in the central part of the range. No mica nor talcose slates accompany the granites, and the only variation in the rocks is as they become more or less sienitic or porphyritic in their composition. Numerous quartz veins, however, are seen toward the eastern side of the pass, crossing the road in a northerly and southerly direction, and projecting above the surface, which in their vicinity is covered with loose pieces of this mineral. These veins resemble the gold-bearing quartz veins of the Southern States, but are unlike those of the Colorado mining district. The granites also of that part of the Rocky Mountain range are very different from those of the Black Hills, being of light colors and gneissoid in structure.

On passing out from the central range toward the plains on the east side, one everywhere meets facing the mountains, a range of high precipitous cliffs of red sandstone, the lower layers often conglomerates. These rocks present a thickness of full 500 feet, and as the lowest strata are not exposed, the formation may be much thicker than this. It is evidently a repetition of the same sandstone group that caps the summit on the west side, and passes under the limestone that forms the western slope. This rock, too, lies in the same relative position to the sandstone on the east side, capping the cliffs in some instances, and also forming a parallel outer range of hills, the strata still dipping east.

All along the east side of the Black Hills, as far as I observed them, and further south, where these hills are lost in the main Rocky Mountain range, this group of marginal cliffs is traced, and everywhere they present a striking feature in the topogra-

phy, all the more marked by the bright red color of the sandstone. Their forms at the Cheyenne Pass, and again at Boulder Creek, Colorado, are represented in the accompanying sections and sketch, and their range is designated in the ground plan or map. The hills appear to have once formed a continuous unbroken line, the western summit presenting a bold escarpment, the base of which is covered by the *debris* fallen from above. This constitutes the gentler slope seen in the section at the western foot of the hills. The eastern slope is that of the strata, and the surface on this side is frequently in chief part that of the rock itself, scantily overgrown with sage bushes, cactus, and grass, that have taken root in the crevices. Behind the first range, with an intervening valley sometimes nearly a mile wide, but much less further south where the dip of the strata is very steep, is a second range of precisely similar form, and near the Cherokee Pass, where the stage-road crosses the mountains, I have observed a succession of four or five such ranges, the outermost one dying away in reduced dimensions in the prairie to the east. Their covering of snow prevented my studying the structure.

At the entrance to the mountains at Clear Creek, Colorado, there is seen extending several miles north and south, outside of this range of hills, another group of basaltic formation. The hills composing it are all remarkable for their peculiar tabular form, being perfectly flat on the summit, which is bounded on all sides by vertical walls, apparently a hundred feet high, of rudely columnar greenstone or hornblende rock. The summits are sometimes several hundred acres in area, and at others (as on one of most striking appearance just east of Golden Gate City) the extent does not seem to be more than three or four acres. In this, however, one may be deceived by the great height of the hill, which is probably full seven hundred feet above its base. These are the only hills of this formation I saw in the Rocky Mountains. Their position is represented in the map, and their form among the sections accompanying it. The soil near their base is quite fertile, and is often cultivated for some distance up their very steep slopes. This group, as also the more extended range of sandstone hills behind them, traced north and south, are seen to be interrupted

at intervals of half a mile to a mile and a half by gaps, all of which are worn down to about the same level, which may be 300 to 500 feet below the summits. The mountain streams find their outlet through these gaps, and all the roads into the mountains pass up by the same openings. The rounding away of the ends of the hills in the gaps toward the east—the direction of the dip—keeps exposed the strata, which in the face of the escarpment further west, occupy a much higher position; and to an observer facing the escarpment the impression is conveyed, that in each hill the strata at its northern end dip north and at the southern end dip south. In the middle of the face they appear to be horizontal, the basset edges only being in view.

The peculiar form of these hills is obviously due to powerful denudation directed from the central range eastward. On the shorter western slope of the Black Hills the effects of the same action in the opposite direction are less strikingly exhibited in the abutment of the same sandstone formation, which, as already noticed, is seen on that side near the summit of the range. Other evidences of extensive movements over the surface from the main Rocky Mountain ranges eastward, will be presented in describing the formations examined further south.

The lower members of the limestone formation at the east entrance of the Cheyenne Pass are remarkably intermixed with various forms of silex, as flint, jasper, carnelian, and chalcedony, which sometimes present a rude agate structure. The flints are of many different colors; the jasper is in fine blocks of clear red. The sides of some of the hills are covered in places with fragments of these minerals—the flints and limestone often attached together.

The operations of the party I accompanied being limited to the pass, I had no opportunity of extending my observations into the plains on the east side of the Black Hills. I had already become satisfied that it is in the plains, and not in the mountains, that the minerals I was in quest of are to be found, and after abandoning further explorations west of the mountains, I proceeded to the region south of Laporte to investigate the character of the beds of coal and iron ore there opened and worked. The range of the formations, I had learned, would carry these

beds northward near the Black Hills, and a knowledge of their properties, which could be obtained in a comparatively settled country, though still covered with snow, would be useful in directing further explorations in the wild districts about the Cheyenne Pass to one provided with the necessary facilities for conducting them in a more propitious season. It was after leaving the pass that I learned from Mr. Duval at Fort Halleck, of the occurrence of iron ore in large quantity on the branches of the Chugwater, about twenty miles north from Camp Walbach, which is an old deserted camp at the east entrance of the Cheyenne Pass. His description of the ore as heavy and massive, with no appearance of a vein or "lead," would apply very well to the localities I afterward examined on South Boulder and Rock Creeks, Colorado; and I imagine the ores of the two districts are of the same character. I was afterward directed by two other old explorers of these regions to the same locality, as the only one where they had observed any iron ores; and another pointed out the same district as containing coal also. It therefore appears to be the most promising spot for subsequent explorations north of the stage route.* At several other localities in the plains there are reports of coal being found. Somewhere on Lodge Pole Creek it is actually worked, to small extent, for supplying in the winter the stage stations near the mouth of this stream. There is also a bed in the plains about seven miles north from the stage road, between Laporte and Latham. This I endeavored to find, but there was no road to it, and the country was covered with snow. A number of these localities are designated upon the map on both sides the Black Hills, as also north of the range on a small branch of the North Fork of the Platte, known as "Trading-house Creek." They indicate satisfactorily the great extent of the area over which beds of coal may be sought with good prospect of finding it. It has been supposed that a bed of it might be found in the black

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* On referring to the report of Captain Stansbury since the above was written, I find on the closing page the following remarks respecting the locality:

"In the bed of the Chugwater, and on the sides of the adjacent hills, were found immense numbers of rounded black nodules of magnetic iron ore, which seemed of unusual richness."

shales, exposed along the road eight miles south from Laporte; but the few imperfect fossils I found here discourage this expectation; as they are referred by Prof. Hall to the tertiary formation.

It is only in the vicinity of Denver, which affords a market for this fuel, that beds of it are worked to any extent. On Coal Creek and on South Boulder Creek, both about twenty-two miles north from this town, a number of beds are opened on the former creek, about fourteen miles east from the base of the mountains, and on the latter within three miles of it. On Coal Creek the outcrop of the coal is at the base of a high hill or ridge, rising back toward the east, and washed at its foot by the creek, which seems to have excavated its bed for some distance in the soft materials of the coal and of the fire-clay beds, that underlie and overlie it. One of the openings commences at the base of this ridge in a heavy body of blue fire-clay, which forms the roof of the coal; and penetrating this, passes into the coal bed itself, which presents a thickness of five feet ten inches pure coal with no mixture of slate. The tunnel has been carried in over one hundred feet, and for this distance the strata are seen to incline at a gentle dip not exceeding 2° or 3° toward the north. The coal is of a brilliant jet black, and is easily mined in large lumps, which appear to be firm and sound. I am informed, however, that after exposure a few weeks to the air, the lumps crumble to fine coal, and for this reason no large stock of it is kept in the coal-yards at Denver. Should the coal not be found to improve in this respect when mined to greater depths, or in other beds not yet opened, there may be difficulties in applying it to the smelting of iron ore, from the small particles clogging the furnace; it may also work to disadvantage in locomotives by sifting through the grate bars. The coal seems to contain but little bitumen, burning with little smoke, no unpleasant odor, and a yellow flame. It does not melt nor coke, and however high the draught, produces no clinker. The ashes of most of the beds are usually white and bulky. A blacksmith who uses it informed me, that he can obtain a welding heat with it in a forge, but with difficulty. Sulphur is observed in it in small quantity in the form of exceedingly thin disks of iron pyrites disseminated through

the seams. Particles of mineral rosin are much more abundant, scattered through the coal, the pieces being of the size of pin-heads. Several other beds of coal have been discovered in the same vicinity ; and one of these, a few rods to the southeast from the point already described, is worked to some extent. This coal bed appears to be an upper one, but though so near the other it has an entirely different dip, which is about 18° east. It is in two positions, the upper being seven feet thickness of coal, separated from the lower, which is four and a half feet thick, by a stratum of dark blue fire-clay eighteen inches thick. The fire-clay appears to be of excellent quality for the manufacture of fire-brick. The mine is worked by following the coal-bed down the slope, and the coal is drawn up on cars by a capstan. No trouble is experienced from water, though the opening already extends about a hundred feet under the hill. The other bed also is dry. I found the workmen attempting to coke the coal of the second bed described, which they thought possessed a better coking quality than that of the other bed. The coke, though very inferior, and obtained only in small pieces, was purchased by the blacksmiths around in preference to the raw coal. A strong fuel such as good coke is of great value in this region, as is shown by the fact of its transportation all the way from Kansas to the machine shops at Central City in the Colorado gold region, where more than a hundred tons of it have already been consumed at a cost of $160 per ton.

The strata accompanying the coal-beds differ in some respects, so far as I could see them, from the strata of the true coal formation. There was the same variety of fire-clay, but the beds of it under the coal contained none of the stigmariæl everywhere else found in this position. I saw no stems and leaves of ferns, but in the fire-clay over the coal, I obtained imperfect fragments of blackened deciduous leaves. Clay iron stone in nodules and layers occurs in the fire-clay. I was told of two layers, together eighteen inches thick in depth of fire-clay. I saw no beds of black shale, nor are any of limestone found in this formation : a few feet above the upper coal bed is a crumbly sandstone of a light gray color. On the extension of this ridge, two and a half miles further north, I examined some ledges which projected through the snow, the position of which I judge is over the coal

and not very far from it. These are thin bedded sandstones of yellowish color, and other layers more compact of bluish shade. The latter contained fossils hells, the substance of which is sometimes well preserved. They are recognised by Prof. Hall as belonging to the genera, cardium, cucullea, mactra, nucula, tellina, and ammonite; thus designating the formation to be as old as the cretaceous period. The deciduous leaves in the fire-clay determine the coal, or rather lignite beds, as belonging to the same formation.

The other coal district is in the hills along South Boulder Creek, only two and a half miles from the base of the Rocky Mountains. Several beds have been opened, and two of them are worked for the supply of the Denver market. This locality also affords an abundance of iron ores, and has been selected for the establishment of the first blast-furnace erected in the territory. This is nearly completed, and will probably go into operation in March. The principal coal-bed is opened a few rods southeast from the furnace, and has been worked one hundred feet down a slope of about ten degrees from the horizontal toward the east. The bed is twelve feet thick, almost uniform in quality, with no intermixture of slate, and presents a beautiful appearance in the brilliant lustre of the coal. A little sulpher (pyrites) may here be detected in the seams. It was from this bed that the first specimen analyzed by Dr. Torrey, whose report accompanies this, was obtained. A second bed is opened about half a mile from the furnace toward Denver. Though further from the mountains, this bed is nearly vertical. It is about seven feet thick, and has been worked to the depth of fifty feet, the coal being raised by means of a horse-whim. A third bed, three to four feet thick, just opened on the north side of the next hill east from the first named coal-bed, is found to be nearly horizontal at its outcrop. This promises to afford coal of a firmer quality than is obtained from the beds heretofore worked.

Other beds are known in this vicinity; and both here and at Coal Creek some of them, I was informed, are consumed by fire, caused, it is supposed, by spontaneous combustion produced by oxidation of the pyrites in the coal.

The fire-clay beds contain the clay iron stone, as on Coal Creek, but no attempts have been made to ascertain its quantity

or quality, and I could not anywhere see it in place. The dependence of the furnace is upon irregular deposits of a shelly hematite, locally known as "top hill ore," found scattered over the summits, ends, and slopes of many of the ridges which border South Boulder Creek and Rock Creek. These deposits extend to a depth of only one to three feet, and as they evidently do not form a part of the strata in the hills, it is impossible to make any estimate of the quantity of ore they will afford. One can judge only from seeing numbers of acres thus covered, that supplies may be obtained for one or more blast-furnaces for several years; but extended observations would be necessary before positively asserting that large works could be supported from this source. The ore is found in pieces of all sizes, up to masses of half a ton weight, and large quantities of it are so fine, that it would have to be collected for the furnace by screening. There is scarcely any intermixture of foreign stony materials in these deposits. The quality of the ore is generally pretty good, though the larger masses are not so fine grained and pure as the smaller ore. I should judge that an average of three tons would be required to make a ton of iron. The ore is in excellent condition for the blast furnace, its long exposure at the surface having prepared it for smelting almost as thoroughly as if it had been roasted. Its unusual mode of occurrence, unconnected with the strata in the hills, was for some time a source of perplexity; and it seemed necessary to explain it correctly, in order to judge better of the probability of the ore being found in large quantities in other places on the range of these formations. On examining the country up to the base of the mountains, I discovered what I believe is the true explanation. At the distance of two and a half miles from the mines, the marginal ridge, already noticed, rises suddenly with a very steep face and dip of its strata, as represented in the section. The surface at its foot is covered with large rounded boulders from the granite rocks of the mountains. Some, also, are of the red sandstones and conglomerates of the outer ridge. They decrease in size and numbers towards the east, indicating the movement in that direction of vast bodies of water or ice. These, together with the evidences of denudation I had observed further north, evidently not referable to the diluvial or drift formation, appeared to me

as more strongly marked evidences of glacial action than I had ever before seen. The extension of this over the hills near the furnace must have excavated the soft beds, of which they are in great part composed; and the light clayey materials of the strata containing the iron ores being swept away by currents of water, these, by their weight, were left behind, and are now found spread over the surface of the hills. By long exposure they have been oxidized and converted from the clay iron stone, or "blue core ore," as it is here called, into the shelly hematite. Such a derivation of the ore, if correct, must itself make the quantity in any locality always uncertain. Found as it is, it is collected and delivered at the furnace at a cost of $3 per ton, making about $9 to the ton of iron.

Most of the materials required for constructing and supplying blast-furnaces, are found in great abundance at this locality. Sandstone of superior quality for building is quarried from extensive ledges, that outcrop on the summit of a ridge within a few rods of the furnace. Blocks of it of uniform thickness are obtained of any desired size. It presents a fine appearance when cut, as seen in the small furnace, which is built of stone thus prepared. The fire-clay beds afford material for fire-brick, with which the furnace is lined; and stones supposed to be sufficiently refractory, found near by, are used for the hearth and boshes of the furnace. An excellent limestone, both for mortar and flux, is found in a little ridge close at the foot of the marginal sandstone hill, along the edge of the mountains, the position and form of which are indicated in the section. In the quarries just opened into this rock, I was so fortunate as to find a few well-marked fossil shells, which will probably determine the age of this formation, as well as of what I believe to be the same limestone, before described as occurring on both sides of the Black Hills. Good clay for common brick is abundant throughout this region. It is largely worked about Denver, where bricks are sold for $8 to $10 per thousand. On Rock Creek, a few miles from the furnace, at the crossing of the road to Denver, an establishment has been in operation for the manufacture of coarse articles of pottery. It is, however, now abandoned. The fuel with which it is intended to supply the furnace is charcoal, made from the pines of the mountains. The

owners of the works requiring only a moderate supply of good iron for their foundry and machine shop at Central City, are not disposed to try experiments at once with the mineral coal so near at hand. They estimate the cost of charcoal at the furnace at ten cents per bushel. The wood is cut by contract at $1 per cord, which is about three cents to the bushel of coal. The coaling will cost three to four cents per bushel, and the hauling the remainder. A difficulty is experienced in making charcoal in this region from the want of good turf for covering the pits. The light soil of the prairies or gravel of the mountains soon falls through among the wood when this is fired.

The furnace, owned by Messrs. Langford, Lee and Marshall, is a very small stack, of daily capacity of only four or five tons of pig iron. It is twenty feet square at base, twenty-two feet high, and seven feet diameter at the boshes. The hearth is five feet high and eighteen inches diameter. It is intended to work the furnace with cold-blast, and the consumption of charcoal will probably be from two hundred and fifty to three hundred bushels to the ton of iron. The cost of fuel in this case will be from $25 to $30, while that of ore, as above stated, may be rated at $9. The cost of the limestone for flux will probably not exceed fifty cents, and the remaining items of labor, repairs, &c., may be estimated at about $7. The total cost will probably be about $45 per ton of pig metal. In large establishments the expenses should be less, especially if the raw mineral coal could be substituted wholly or in part for the charcoal. The quantity of fuel, too, would be diminished by the use of the hot blast.

The prairie country bordering the mountain toward the east, which presents the same geological and topographical features through Colorado to the North Fork of the Platte River, will, no doubt, be found to afford throughout this extent similar resources for the support of a population dependent upon agricultural and manufacturing pursuits. Though deficient in forests, the lack of wood will be compensated by the abundant supplies of mineral coal, the existence of which has already been detected, even to the southern portions of Colorado. In that region there are also found springs of petroleum, and the manufacture of kerosene oil is already carried on to small extent near Cañon City, for the supply of the Denver market.

The agricultural resources of the prairies are somewhat limited by the extreme dryness of the climate. Rain seldom falls, and were it not for the never failing supplies of water in the numerous streams running from the snowy central range of the Rocky Mountains, the country would be an uninhabitable desert. Yet the soil is in great part fertile, warm and mellow, and abounds in gypsum and salts of soda, which appear upon the surface in the form of a white incrustation resembling frost. This is particularly abundant around the edges of dried up ponds. The alkaline salts affect the waters of many of the wells, rendering them nauseous to the taste and unwholesome, and mixing with the dust of the roads this is said to be in the summer season very injurious to the eyes of travellers. It is remarkable, that notwithstanding the want of rain, no great trouble is experienced over the plains for the want of water at the ranches and stations along the roads. I crossed the Platte River at Fort Kearney in October, over its dry sandy bed, and yet the wells along the valley contained abundant water, and in general they were not twenty feet deep, their bottoms not reaching to the level of the stream. It is difficult to explain from whence these supplies are derived. The dryness of the soil renders irrigation necessary for its successful cultivation, and this is already practiced to a considerable extent in Colorado after the system of the Mexicans, which consists in the excavation of *acequias* or ditches, often several miles in length, by which the water of the streams taken out at an upper level, is carried at this elevation past the farming lands, over which it is let out as occasion requires by tapping the *acequias* at any desired points. The cultivation is thus limited to lands lying below the level of the *acequias;* and such lands are met with of considerable extent along most of the streams, spreading out to great width, even before these have fairly emerged from the mountains. Very productive and extensive farms thus situated are seen running up among the basaltic hills on Clear Creek, and similar improvements extend all along this stream to its mouth below Denver. The streams north of it, so far as, and including the *Cache á poudre*, afford the same advantages for cultivation of the soil, and along most of them the lands are occupied in continuous lines of farms. In the newness of the

country, which has been occupied only two or three years, the crops are limited to a few of the most necessary articles. Flour being supplied to the territory from the States and New Mexico, the cultivation of wheat is not so important as of the more bulky articles, which will not pay for transportation from such distances. Some wheat, however, is raised, and the crop is a successful one. But attention is chiefly directed to procuring the large supplies of hay, corn, oats, and vegetables, required by the numerous gold-mining population in the mountains. The hay being made from the wild prairie grass, its supply is limited only by the amount of labor employed in cutting and stacking it; still, owing to an overstock of it the previous year, the quantity put up in 1863 has proved too small for the demands of the country, increased as they are by the extraordinary accumulations of snow, which, covering the plains, cut off the herds of cattle and horses, with which the country is abundantly stocked, from their accustomed support by grazing during the winter. This, together with the obstructed condition of the roads caused the price of hay in December last, to rise to $105 per ton at the gold mines. Corn, which is a good crop, and may be raised to any extent along the streams, was worth at the same time nine or ten cents per pound. Potatoes are produced in abundance, as also onions, cabbages, and many other vegetables; but in this unpropitious season the prices of all these range very high. Onions are raised with scarcely any of the labor attending their cultivation in the States, yet they were from ten to twelve cents a pound. They grow so luxuriantly that a single one often weighs more than a pound. Such prices cannot be sustained in a favorable season, and particularly when the country is supplied with a more numerous agricultural population.

It is an important question, whether the cultivation of these prairies is always to be limited to those portions capable of being irrigated only by the system now in use. The mountains, it appears, are abundantly provided with water, derived chiefly from the melting of the snows in the great Central Range. A large part of this, without doubt, penetrates under the stratified rocks, which on both sides dip away from the mountains. These waters probably flow in underground channels far from the mountains, and if tapped by Artesian wells sunk down to them, they might

reasonably be expected to rise to the surface in never-failing springs. The stratification of the country is certainly remarkably encouraging to such an enterprise; and another inducement to its prosecution would be the discovery of the mineral beds, whatever they may be, beneath the surface. This would be a certain and most economical method of determining the existence or non-existence of beds of coal in localities where it might be especially desirable to obtain this fuel. Artesian wells must at some time be exceedingly useful at Laramie Plains, which are not so well watered as the country east of the mountains. These plains, hitherto entirely uncultivated, afford in places good pasturage, and a considerable amount of prairie-grass hay, for the use of the overland stage line and of emigrants.

I left Colorado on the 19th of December, and being delayed several days in my journey through Iowa by the extreme severity of the winter season, arrived in New York on the 9th of January.

Very respectfully, I am yours,

JAMES T. HODGE.

New York, January 22, 1864.

New York, February 13, 1864.

J. T. HODGE, Esq.:

Dear Sir,—I have carefully examined and analyzed the samples of coal, that you brought from the Rocky Mountains and placed in my hands. The specimens, according to the labels attached to them, are from two localities, viz., Coal Creek and Boulder Creek.

Those from the former place were taken, as you state, from a bed more than ten feet in thickness. The mineral has nearly the hardness of ordinary anthracite, but is much more brittle. The fragments are often cuboidal or rhomboidal, and in some of them a little amber was detected. The lustre is bright and shining. The coal does not stain the fingers. The powder is

black when viewed in a heap, but when a thin film of it is spread upon a white surface, it has a slight tint of brown. Specific gravity, 1.29. When heated in a glass tube, the temperature of which is gradually raised to 400° or 500° F., it gives off water, the last portions of which contain a little empyreumatic oil or tar. At a dull red heat it takes fire, burning with a bright yellow and smoking flame, emitting an odor between that of heated bituminous coal, and that of imperfectly burning wood. Some of the fragments gave out a slight odor of sulphur, which was traced to minute scales and spangles of iron pyrites, scattered here and there among the lumps. Compared however with most bituminous coals, this mineral fuel is remarkably free from sulphur. When submitted to analysis, it yielded the following results:

Water in a state of combination, or probably its elements, as in dry wood	20.00
Volatile matter, expelled at a red heat in the form of inflammable gases and vapors	19.30
Fixed carbon	58.70
Ash, consisting chiefly of oxide of iron, alumina, and a little silica	2.00
	100.00

The ash is mostly reddish, but sometimes light gray. Another specimen contained only 16 per cent. of water.

The coal from Boulder Creek, which occurs in a bed four feet thick and in another ten feet, has a general resemblance to that from the other locality, It is, however, more dense, having a specific gravity of 1.4, and is less brittle, and the fracture is not so glossy. It contains also flakes of mineral charcoal scattered through the mass, and the proportions of its constituents differ considerably from those of the Coal Creek bed, it being a stronger fuel. It contains a little sulphur like the other. The composition is as follows, viz.:

Water in a state of combination, or its elements.....	12.00
Volatile matter expelled at a red heat in the form of inflammable gases and vapors.....	26.00
Fixed carbon.....	59.20
Ash, of a reddish color, or sometimes gray.....	2.80
	100.00

From the characters and analyses of the specimens here described, it will be seen that the Rocky Mountain coal belongs to the class of lignites, and that it is not technically a bituminous coal, neither cannel nor an anthracite. Still in common parlance it will be regarded as coal. The geological character of the rocks in which the mineral is found, will, I suppose, be given by yourself and Professor Hall. In calorific power the Rocky Mountain coal may be placed between dry wood and bituminous coal, and therefore it is a most valuable fuel, especially where bituminous coal and anthracite are not likely ever to be found, and fire-wood is difficult to procure. I see no reason why it may not be used for the smelting of iron and other ores. For locomotives it could be employed to advantage, with some modification of the fire-place. The ash is so small in quantity, and so light, that most of it would be carried off by the blast of the furnace. From my own trials, I find that the coal burns freely in a small stove, making a hot and clear fire, and leaving no clinkers. The specimens that I have examined show a tendency to break up and crumble after they have been soaked with water and allowed to dry, so that it would be well to preserve the coal as much as possible from being wet by rain. The lumps that you brought home from your journey show no disposition to crumble in a *dry place.*

In conclusion, I remark, that the discovery of such extensive beds of a good mineral fuel is of the highest importance to the section of country in which they occur.

The iron ore is limonite, commonly known by the name of brown hematite or brown iron ore. It is a compact variety and is certainly derived from carbonate of iron, some of which in an unaltered state is evident in one of the specimens. The carbonate will probably be found in larger proportion, as the

beds are worked further in beyond the reach of atmospheric influence. There is reason to believe that the iron obtained from this ore will be of good quality.

Yours respectfully,

JOHN TORREY.